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Research Article

Electrolyte and acid-base imbalances and kidney function in children with acute diarrhea: A study from Dr. Soetomo General Academic Hospital 2021–2023

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ABSTRACT

Diarrhea is the third leading cause of death in children under five, causing nutritional deficits that hinder growth, cognitive, and academic performance. Each episode before the age of 2 years increases the risk of stunting by 5%. Systematic data, such as sociodemographic, clinical characteristics, and laboratory characteristics, are important for prevention. This descriptive observational study used a retrospective design based on medical records of children with acute diarrhea treated at Dr. Soetomo General Hospital, Surabaya, from 2021 to 2023. A total of 461 subjects met the criteria; 429 underwent electrolyte imbalance testing, 198 were assessed for urea and creatinine levels, and 68 had their acid-base balance evaluated. A total of 288 subjects (62.5%) were male children; 262 patients (75%) were 0-12 months old; 253 (61%) had good nutritional status; 339 (73.5%) underwent therapy for less than 1 week; and 402 patients (65%) recovered. A total of 40% experienced mild-moderate and severe dehydration with neurologic (16.4%) and respiration comorbidities (16.2%). Electrolyte disturbances included hyponatremia (33.1%), hypokalemia (12.1%), hyperchloremia (50.2%), increased urea (28.3%), abnormal creatinine (35.4%), hypobicarbonate (75%), and acidosis (63.2%). Therefore, early detection and appropriate management are essential to mitigate further complications and improve recovery outcomes.

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INTRODUCTION

Diarrhea is characterized by the passage of loose or watery stools three or more times within a 24-hour period, with the acute form referring to cases in which this condition persists for no longer than 14 days (Nemeth & Pfleghaar, 2022). According to the WHO, diarrheal disease is the third leading cause of death in children under five years old and accounts for approximately 443,832 child deaths annually. According to the latest data from the 2020 Indonesian Nutrition Status Survey (SSGI), the national prevalence of diarrheal disease was approximately 9.8% (Suparmi et al., 2025). Surabaya is recorded as the city with the most diarrhea cases in East Java, with 22,327 cases out of 183,338 (Badan Pusat Statistik Provinsi Jawa Timur, 2022).

Acute diarrhea commonly induces metabolic acidosis through bicarbonate loss in stools. Blood gas analysis, together with renal function assessment, provides essential information on the severity of this disturbance and helps prevent complications such as acute kidney injury and severe metabolic imbalance. In addition to being one of the main causes of death in children, recurrent diarrhea in children can cause stunting, so systematic data collection, analysis, and interpretation are needed to minimize the potential for outbreaks and prevent public health emergencies.

METHODS

This study is a descriptive observational study using retrospective secondary data from patient medical records in the Department of Child Health at Dr. Soetomo General Academic Hospital, Surabaya, Indonesia. The sample used in this study was all pediatric patients under 5 years old diagnosed with acute diarrhea at Dr. Soetomo General Academic Hospital during the 2021-2023 period. The inclusion criteria were children below the age of 5 years with a main acute diarrhea diagnosis in the hospital, while the exclusion criteria were children below the age of 5 years with a main acute diarrhea diagnosis who were hospitalized and had incomplete or illegible medical records.

A total of 461 medical records of children diagnosed with acute diarrhea were obtained. The data obtained from medical records included gender, age, domicile, length of stay, treatment outcome, degree of dehydration, comorbidities, nutritional status, electrolyte disturbances, kidney function disturbances, and acid-base disturbances. Nutritional status in this study was determined based on WHO Z-score standards, and the degree of dehydration was classified according to WHO guidelines. All obtained data were then analyzed using IBM SPSS software. This study has received approval from the Ethics Committee of Dr. Soetomo General Academic Hospital with decision letter number 1822/LOE/301.4.2/XI/2024.

RESULTS

Based on this study, there were 288 male patients (62.5%) and 173 female patients (37.5%), with an age range of 0-12 months accounting for 262 patients (56.8%), followed by 13-24 months with 150 patients (32.5%), 25-36 months with 44 patients (9.5%), and 37-48 months with 5 patients (1.2%). A total of 325 pediatric patients (70.5%) diagnosed with diarrhea were from Surabaya, and 136 patients (28.6%) were from rural areas. The domicile of pediatric patients from rural areas was dominated by Sidoarjo (30 patients, 22.1%), Jombang (16 patients, 11.8%), and Bangkalan (10 patients, 7.4%). The length of stay for pediatric patients diagnosed with diarrhea was less than 1 week (76.2%), while patients with a length of stay of more than 1 week numbered 122 (29.5%).

A total of 402 patients treated at Dr. Soetomo General Academic Hospital were discharged due to recovery from diarrhea symptoms (56%)

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or improvement in diarrhea symptoms (36.3%). A total of 44 children (9.5%) were referred to a different hospital, and 15 children (3.3%) were deceased.

Based on Table 2, 260 pediatric patients (56.5%) experienced diarrheal disorders with mild-moderate dehydration, 36 patients (7.8%) without dehydration, and 26 patients (5.7%) with severe dehydration. A total of 281 pediatric patients (87.5%) had comorbid symptoms, and 180 (12.5%) patients were diagnosed with diarrhea without comorbidities. Comorbidities involving multiple organ systems, such as respiratory ailments including asthma and pneumonia, were present in 16.2% of patients. Congenital anomalies such as Down syndrome, microcephaly, and Pierre Robin syndrome accounted for 14.6% of comorbid states observed. Hematologic conditions, notably anemia, were identified in 12.3% of cases. Neurological disorders, comprising febrile convulsions, epilepsy, encephalopathy, and meningoencephalitis, also featured among the patient profiles.

Furthermore, genitourinary abnormalities were documented in 13.9% of the cohort, cardiovascular diseases in 9.4%, and endocrine disorders in 13.5%. Musculoskeletal involvement was minimal, with a split foot recorded in only 0.3% of patients. A total of 415 patients had their nutrition assessed, with 253 patients (61%) having good nutrition, followed by severely wasted in 77 patients (18.5%), wasted in 56 patients (13.5%), and overnutrition in 29 patients (7%).

Table 1. Sociodemographic Data of Children Patients at Dr. Soetomo General Academic Hospital 2021-2023 (n=461)

Sociodemographic characteristic	n (%)
Gender	
Male	288 (62.5)
Female	173 (37.5)
Age (month)	
0-12	262 (56.8)
13-24	150 (32.5)
25-36	44 (9.5)
37-48	5 (1.2)
Domicile	
Urban	325 (73.5)
Rural	136 (26.5)
Length of stay	
Less than 7 days	339 (73.5)
More than 7 days	122 (26.5)
Outcome	
Discharged	402 (87.2)
Referred	44 (9.5)
Deceased	15 (3.3)

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Table 2. Clinical Characteristics of Children with Diarrhea at Dr. Soetomo General Academic Hospital 2021-2023

Clinical Characteristics (n=461)	n (%)
Degree of dehydration (n = 322)	
Severe dehydration	26 (8.1)
Mild to moderate dehydration	260 (80.8)
Non Dehydration	36 (11.2)
Comorbidities	
With comorbidities	281 (61.0)
Anemia	42 (4.2)
Pneumonia	35 (3.5)
Urinary Tract Infection	32 (3.2)
Hypothyroid	30 (3.0)
Atrial Septal Defect	28 (2.8)
Down Syndrome	26 (2.6)
Sepsis	15 (1.5)
Ventricular Septal Defect	14 (1.4)
Asthma	13 (1.3)
Without comorbidities	180 (39.0)
Nutritional status (n=415)	
Overnutrition (> +2SD)	29 (7.0)
Good nutrition (-2 SD ≤ z ≤ +2 SD)	253 (61.0)
Wasted (-3 SD ≤ z < -2 SD)	56 (13.5)
Severely wasted (z < -3 SD)	77 (18.5)

Table 3. Clinical Symptoms of Children with Diarrhea at Dr. Soetomo General Academic Hospital 2021-2023

Clinical Symptoms (n=40)	n (%)
Nausea and vomiting	19 (47.5)
Fever	28 (70.0)
Seizures	12 (30.0)
Sunken eye	13 (32.5)
Shortness of breath	18 (45.0)
Anemia	9 (22.5)
Cyanosis	3 (7.5)
Watery stool	31 (77.5)
Soft stool	9 (22.5)

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Table 4. Electrolyte Serum of Children with Diarrhea at Dr. Soetomo General Academic Hospital 2021-2023

Serum Electrolytes Characteristic (n=429)	n (%)
Sodium	
Hyponatremia (< 135 mEq/L)	142 (33.1)
Normonatremia (135-145 mEq/L)	246 (57.3)
Hypernatremia (> 145 mEq/L)	41 (9.6)
Potassium	
Hypokalemia (< 3.5 mEq/L)	52 (12.1)
Normokalemia (3.5-5.5 mEq/L)	336 (78.3)
Hyperkalemia (> 5.5 mEq/L)	41 (9.6)
Chloride	
Hypochloremia (< 96 mEq/L)	26 (6.1)
Normochloremia (96-106 mEq/L)	188 (43.8)
Hyperchloremia (> 106 mEq/L)	215 (50.1)

According to Table 3, the medical records of 40 children with acute diarrhea were reviewed to assess accompanying clinical features. Fever was the most frequently observed symptom, affecting 28 patients (70%), followed by nausea and vomiting in 19 patients (47.5%) and shortness of breath in 18 patients (45%).

Other notable findings included sunken eyes in 13 patients (32.5%), seizures in 12 patients (30%), and anemia in 9 patients (22.5%), while cyanosis was relatively uncommon, occurring in only 3 cases (7.5%). Regarding stool characteristics, watery stools were predominant, documented in 77.5% of patients, whereas soft stools were observed in 22.5

In Table 4, 429 pediatric patients were assessed at admission to the pediatric ward, and their electrolyte profiles were evaluated. Regarding sodium balance, 142 patients (33.1%) had hyponatremia, 246 patients (57.3%) maintained normonatremia, and 41 patients (9.6%) had hypernatremia. Potassium abnormalities were also documented: 52 patients (12.1%) with hypokalemia, 336 patients (78.3%) within the normal range, and 41 patients (9.6%) with hyperkalemia. Chloride levels showed a different distribution, as hyperchloremia was the most common finding, occurring in 215 patients (50.1%), followed by normochloremia in 188 patients (43.8%) and hypochloremia in 26 patients (6.1%). These findings indicate that while normonatremia and normokalemia were the predominant patterns, disturbances in sodium, potassium, and particularly chloride balance were frequent among this cohort, underscoring the clinical relevance of monitoring electrolyte status in pediatric patients with diarrhea.

In Table 6, 68 patient samples had blood gas parameters assessed at admission to the pediatric ward. A total of 51 pediatric patients (75%) had low HCO3 levels, 9 (13.2%) had normal HCO3 levels, and 8 (11.8%) had high HCO3 levels.

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Table 5. Urea and Creatinine Serum of Children with Diarrhea at Dr. Soetomo General Academic Hospital 2021-2023

Kidney Function Characteristic (n = 198)	n (%)
BUN	
Normal BUN (< 20 mg/dl)	142 (71.7)
Abnormal BUN (> 20 mg/dl)	56 (28.3)
Creatinine	
Normal creatinine (< 0.7 mg/dl)	128 (64.6)
Abnormal creatinine (> 0.7 mg/dl)	70 (35.4)

Table 6. Blood Gas Analysis of Children with Diarrhea at Dr. Soetomo General Academic Hospital 2021-2023

Blood Gas Characteristic (n = 68)	n (%)
HCO3	
Low HCO3 (> 22 mEq/L)	51 (75.0)
Normal HCO3 (22-26 mEq/L)	9 (13.2)
High HCO3 (< 26 mEq/L)	8 (11.8)
PCO2	
Low PCO2 (> 35 mmHg)	38 (55.9)
Normal PCO2 (35-45 mmHg)	15 (22.1)
High PCO2 (< 45 mmHg)	15 (22.1)
pH	
Acidosis (< 7.35)	43 (63.2)
Normal pH (7.35-7.45)	21 (30.9)
Alkalosis (> 7.45)	4 (5.9)

A total of 38 pediatric patients (55.9%) had low PCO2 levels, 15 (22.1%) had normal PCO2 levels, and 15 (22.1%) had high PCO2 levels. A total of 43 pediatric patients (63.2%) experienced acidosis; 21 (30.9%) did not experience acid-base disturbances; and 4 (5.9%) experienced alkalosis.

DISCUSSION

At Dr. Soetomo General Academic Hospital (2021–2023), most diarrhea cases in children occurred in the 0–12-month age group (56.8%). These findings align with Edelu et al. (2020), who reported that the most susceptible age group for diarrhea among children was 0–12 months (47.2%). Similarly, Jordan et al. (2020) reported greater susceptibility to diarrhea in children aged 0–12 months compared to those older than 12 months. This may be attributed to incomplete development of digestive enzymes in children under 3 years, leading to less efficient nutrient absorption (Adiba et al., 2022).

In this study, acute diarrhea in children was more prevalent among males (62.5%). This is consistent with findings by Ezuruike, Ibeneme, and Uwaezuoke (2022), who reported that male children accounted for 59 cases (54.6%), and with Kurniawan et al. (2025), who likewise

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observed male predominance. The higher incidence in boys may be linked to greater physical activity, which increases exposure to infectious agents and thereby elevates susceptibility (Adiba et al., 2022).

At Dr. Soetomo General Academic Hospital, the main electrolyte disturbances in children with diarrhea were hyponatremia (33.1%), hypokalemia (12.1%), and hyperchloremia (50.2%). Comparable studies reported varying patterns: Soudre et al. (2023) observed hyponatremia (25%), hyperkalemia (12.5%), and hyperchloremia (75%); Joseph and Keithellakpam (2023) found hyponatremia (45.4%), hypokalemia (38.9%), and hypochloremia (71.8%); Arif et al. (2021) identified hyponatremia (30.77%) and hypokalemia (40%) as most frequent; while Rehana et al. (2022) noted hyponatremia (55.28%) and hypokalemia (43.9%) as predominant.

In acute rotavirus diarrhea, enterochromaffin cell–derived serotonin activates 5-HT3 receptors in the myenteric plexus, inducing VIP release and elevating cAMP in epithelial cells, which drives sodium and water secretion (Crawford et al., 2017). Dehydration subsequently activates the renin–angiotensin–aldosterone system; aldosterone stimulates ENaC, enhancing sodium reabsorption but increasing potassium loss, leading to hypokalemia (Fountain, Lappin, & Kaur, 2023). This is due to a decline in blood pressure or serum sodium, which activates juxtaglomerular renin release, triggering angiotensin II-mediated aldosterone synthesis that regulates sodium and potassium balance (Scott, Dunn, & Menouar, 2023). Hyperchloremia arises from bicarbonate depletion, with chloride retention maintaining extracellular electroneutrality (Sharma & Aggarwal, 2019).

A total of 128 patients had normal creatinine levels (64.6%), and 70 had high creatinine levels (35.4%). This is consistent with research by Kumar and Chakravarthi (2019), in which children with diarrhea had normal serum creatinine levels (68%). A total of 56 patients (28.3%) had high BUN levels, and 142 (71.7%) had normal BUN levels. A study by Shankar, Mahamud, and C. A. (2020) identified 27 patients with elevated BUN levels among 117 samples. Similar findings in Kumar and Chakravarthi (2019) where 64.9% of 97 patients had high serum BUN. Dehydration reduces plasma flow, leading to increased urea reabsorption in the collecting ducts and elevating serum urea levels (Ibrahim, Umboh, and Manoppo, 2024).

Acid-base disturbances were dominated by low HCO3 levels (75%), low PCO2 (55.9%), and acidosis (63.2%). Similar findings in Edelu et al. (2020), found that metabolic acidosis is more prevalent in acute diarrhea. Metabolic acidosis in diarrhea results from bicarbonate loss through stool, intensified by ongoing pancreatic and mucosal secretion (Sharma & Aggarwal, 2019). In cases of severe dehydration, diminished renal perfusion limits acid excretion, while tissue hypoxia promotes lactic acid accumulation, further aggravating acidosis (Adiba et al., 2022). Because this study used a retrospective approach, it relied on existing medical records as the primary data source. As a result, missing or insufficient clinical information may have affected the precision of the findings.

CONCLUSION

The profile of children patients diagnosed with acute diarrhea at Dr. Soetomo Hospital, Surabaya, in 2021-2023 shows that male infants in the 0-12-month age group were from urban backgrounds, had a length of stay of less than a week, and were mostly

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discharged. Children patients diagnosed with diarrhea were experiencing mild to moderate dehydration with respiratory comorbidities. Most of the infants have good nutritional status. Electrolyte disturbances diagnosed with diarrhea at Dr. Soetomo Hospital, Surabaya, were hyponatremia, hypokalemia, hyperchloremia, increased BUN and creatinine levels, low HCO3, low PCO2, and acidosis.

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